Technical Manual for
Mini Scaler
Model MS-3

eberline

eberline service centers

July 1, 1980

Certified Calibration and Repair

Eberline Instrument Certified Calibration	Call Service Center for prices.
Other Manufacturer Instrument Certified Calibration	$100.00 each
Repair Rate Above Calibration plus Parts at List Price	$60.00/hr.

Contractual rates are available on periodic repair and/or calibration. Contact Service Center for prices.

Three (3) Year Extended Warranty:

This includes Certified Calibration plus Parts

1. Eberline Instruments, FOB Eberline Customer Service Facility	$70.00 each/quarter

Miscellaneous:

1. Turn Around Time:

   Calibration — Five (5) working days on Eberline instruments

   Repair — Twelve (12) working days on Eberline instruments, unless parts have to be ordered.

2. FOB Santa Fe, New Mexico or West Columbia, South Carolina

3. Instruments for warranty repair, repair, or calibration must be sent to:

Mr. Henry Gomez
Customer Service
Eberline Instrument Corporation
P.O. Box 2108, Airport Road
Santa Fe, New Mexico 87501
Telephone: 505/471-3232

Mr. John Witzell
Customer Service
Eberline Instrument Corporation
312 Miami Street
West Columbia, South Carolina 29169
Telephone: 803/796-3604

4. In addition, the following Customer Service Centers are available for customers outside the United States.

Eberline Instrument Co., Ltd.
Church Street
Dorking Surrey
England, RH41DQ
Telephone: 44-306-87836

Saskatchewan Research Council
Attn.: Mr. Don Barnett
30 Campus Drive
Saskatoon, Saskatchewan
Canada, S7N 0X1
Telephone: 306/664-5433

Prices at these locations will vary from U.S. prices. Please contact the facilities for current price and delivery information.

EBERLINE INSTRUMENTS STANDARD WARRANTY

One Year Warranty: Seller warrants to replace or repair, at its option, any products or parts thereof (excluding tubes, crystals and batteries [tubes and crystals 90 days]) which are found defective in material or workmanship within one year from date of shipment. Seller's obligation with regard to such products or parts shall be limited to replacement or repair, FOB seller's factory or authorized repair station, at seller's option. The aforesaid warranty does not cover normal life-end failure of components and will be voided if repair has been attempted by other than seller's authorized personnel. In no event shall seller be liable for consequential or special damages, transportation, installation, adjustment, work done by customer or other expenses which may arise in connection with such defective product or parts.

Exclusion of Warranties and Limitation of Liability: **The foregoing warranty is expressly made in lieu of any and all other warranties express or implied including the warranties of merchantability and fitness for a particular purpose. Under no circumstances shall seller be liable for any indirect, special, incidental or consequential damages to customer or to any third party.**

eberline

P.O. BOX 2108, SANTA FE, NEW MEXICO 87501
PHONE: (505) 471-3232 TWX: 910-985-0678

LIST OF EFFECTIVE PAGES

TOTAL NUMBER OF PAGES IN THIS MANUAL IS 26, CONSISTING OF THE FOLLOWING:

Page	Change in Effect	Latest Publication Date
Title	Change 1	August 28, 1978
A	Change 5	November 28, 1978
i	Change 1	November 28, 1978
ii	Change 1	November 28, 1978
1	Change 2	November 28, 1978
2 through 5	Original	July 30, 1973
6	Change 1	November 28, 1978
7 through 14	Original	July 30, 1978
15, 16	Change 3	November 28, 1978
17	Change 5	November 28, 1978
18	Change 4	August 18, 1978
19	Change 1	June 5, 1974
20	Change 2	June 11, 1976
21	Change 1	June 5, 1974

Pages 12 and 22 are blank.

TABLE OF CONTENTS

Section Page

I GENERAL

Purpose and Description . . . 1
Specifications . . . 1

II OPERATION

Description of Controls and Connectors . . . 3
Preparation for Use . . . 3
Operation Check . . . 3
Operating the Instrument . . . 3
Practical Considerations of Counting Random Events (Radioactivity) . . . 4

III THEORY OF OPERATION

General . . . 9
Functional Theory . . . 9

IV MAINTENANCE

Disassembly and Reassembly . . . 13
Preventive Maintenance . . . 13
Calibration . . . 13
Troubleshooting . . . 13

V PARTS LIST 15

VI DIAGRAMS 18

LIST OF ILLUSTRATIONS

Figure Page

1-1 Mini Scaler, Model MS-3 . . . ii
2-1 Model MS-3, Rear View . . . 2
2-2 Model MS-3, Interior View . . . 2
2-3 Typical High Voltage vs H.V. Adjust Setting . . . 4
2-4 Typical H.V. Plateau, Model MS-3 with PG-2 Detector . . . 5
2-5 Typical Plateau, Model MS-3 with FC-2 Detector . . . 6
3-1 System Block Diagram . . . 8
3-2 Counting Patterns for 7490 and 7492 . . . 10
3-3 Logic States in Timer Control . . . 11
6-1 General Schematic, Model MS-3, Sheet 1 of 2 . . . 18
6-1 General Schematic, Model MS-3, Sheet 2 of 2 . . . 19
6-2 Component Layout of P-201AS Board . . . 20
6-3 Component Layout of Amplifier-Discriminator Board . . . 20
6-4 Component Layout of Scaler Board . . . 21
6-5 Component Layout of Timer Board . . . 21

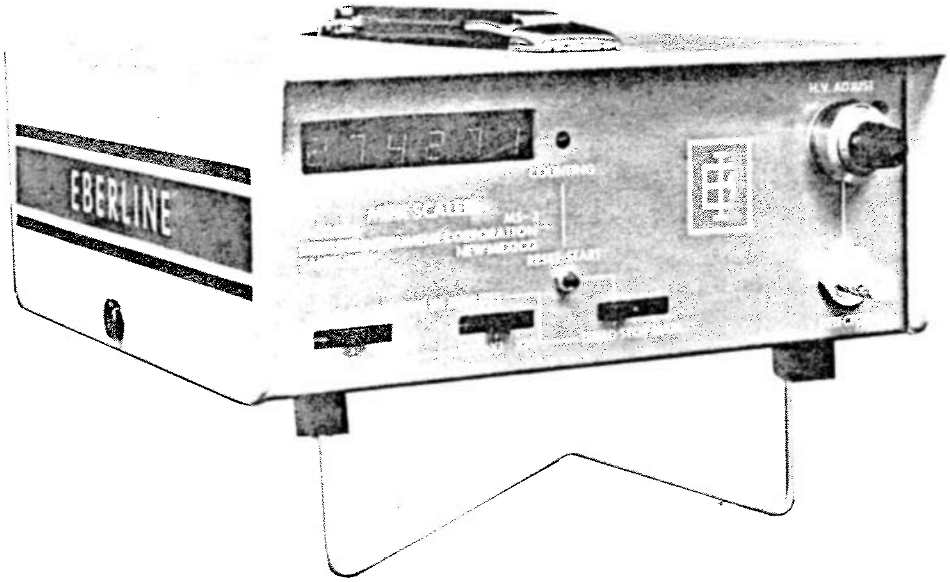


Figure 1-1. Mini Scaler, Model MS-3

SECTION I
GENERAL

A. PURPOSE AND DESCRIPTION

The MS-3 Mini Scaler is a complete system consisting of a variable high voltage supply, charge sensitive input amplifier, six decade scaler, and timer. All circuits are solid state with extensive use of integrated circuits to enhance reliability.

It is designed for use with practically any scintillation, Geiger-Mueller or proportional detector.

The scaler section uses the latest design in light emitting diode readouts. Battery operation is available by use of an external battery which can be plugged into the rear panel connector.

B. SPECIFICATIONS

1. High Voltage: Regulated, adjustable by front panel control from 200 volts to approximately 2500 volts and can supply a 100 megohm load up to 1700 volts. A ten turn potentiometer allows repeatable predetermined voltage setting. The supply (EIC Model P-201AS) is a plug-in module for ease of maintenance.

2. Scaler: Six each light emitting diode readouts. Counting light stays lit when in counting mode. Decade counters and counting gate are plugged in for ease of maintenance.

3. Timer: Preset times from 0.1 minute to 50 minutes in a 1, 2, 5 sequence referenced to 60 Hz line frequency yielding an accuracy typically better than 0.05%. All integrated circuits are plugged in for ease of maintenance. The timer has an oscillator for use with battery or 50 Hz line. The capability of syncing with a 50 Hz line is incorporated in the timer circuitry. For this procedure refer to Section IV, C, 1.

4. Amplifier: Charge sensitive input allowing very high input sensitivity with excellent noise rejection, followed by a dc coupled amplifier fed back for stability and control. Overall sensitivity adjustable by an internal gain control from 0.12 to 1.2 picocoulombs (approximately 1 to 10 millivolts on voltage sensitive input).

5. Instrument Resolution: Two microseconds with pulse height two times threshold.

6. RESET-START: Resets scaler and timer to zero and starts a timed count.

7. TIMED-STOP-MAN: Selects counting mode. TIMED position automatically stops count after preset time selected on timer. MAN. position counts continuously. STOP position does not count.

8. DETECTOR: MHV series coaxial.

9. POWER: Line – 115 or 230 ±10% VAC switch selectable 50/60 Hz, 1/4 amp, 3-wire. Battery – Any battery 7.5 volts minimum, 14 volts maximum at 1.0 amp load.

10. Temperature: Operational from 32 to 140°F (0 to 60°C).

11. MECHANICAL

a. Size: 4-1/2" H x 9-5/8" D x 8-1/4" W, including controls (11.4 x 24.4 x 21 cm).

b. Weight: 5-3/4 pounds (2.6 kg).

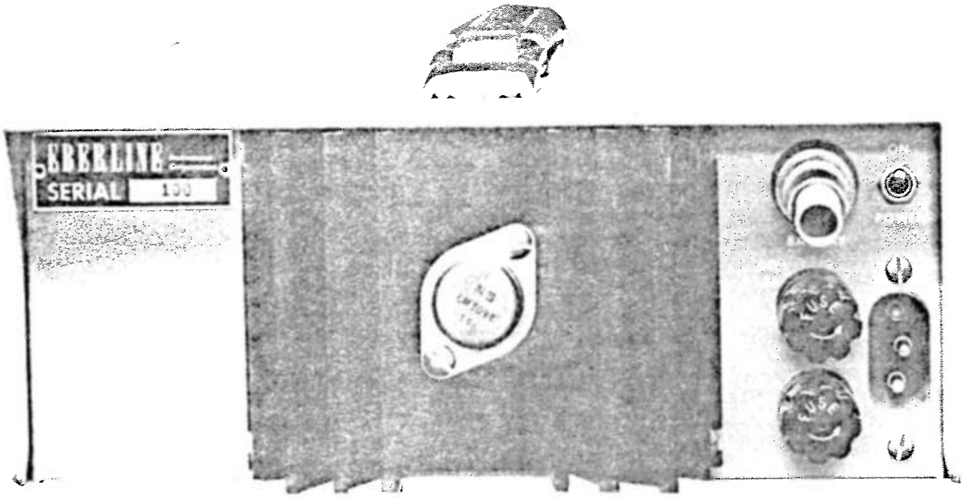


Figure 2-1. Model MS-3, Rear View

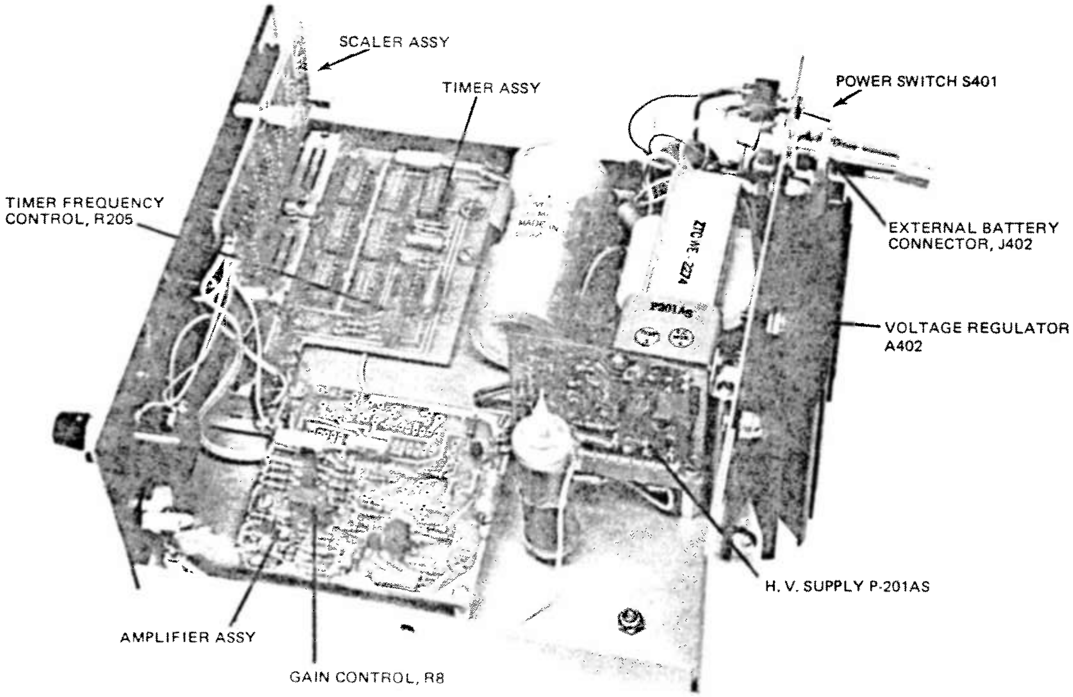


Figure 2-2. Model MS-3, Interior View

SECTION II
OPERATION

A. DESCRIPTION OF CONTROLS AND CONNECTORS

1. EXTERNAL (See Figures 1-1, 2-1, 2-2)

a. DETECTOR: Connection to detector. MHV series coaxial.

b. H.V. ADJUST: Ten turn calibrated dial for setting and changing high voltage.

c. TIMED-STOP-MAN: Switch to select counting mode.

d. RESET-START: Switch to reset all appropriate circuitry to zero and start a counting sequence.

e. COUNT TIME IN MINUTES: Switches to select desired counting time.

f. POWER: Switch to supply power to instrument (Rear Panel).

g. BATTERY: Connector for plugging in external battery (Rear Panel).

2. INTERNAL

a. Gain (Amplifier Board): Control for adjusting gain of amplifier.

b. Time (Timer Board): Control to calibrate time base when operating with external battery.

B. PREPARATION FOR USE

1. The instrument should be checked for physical damage.

2. Set the AC power input switch, located on bottom of instrument, to correspond to the voltage to be used.

3. Plug power cord into power source or connect to battery power through BATTERY connector (pin 1 negative, pin 2 positive.

4. Turn POWER switch ON and push RESET-START switch. The readouts should be blanked out.

C. OPERATION CHECK

1. Set TIMED-STOP-MAN switch to MAN. Count light should come on.

2. Set TIMED-STOP-MAN switch to TIMED.

3. Set COUNT TIME IN MINUTES switches to 1 and X.1. Press RESET-START switch. Units should stop counting after 6 seconds. Count light should go off.

D. OPERATING THE INSTRUMENT

1. G-M DETECTORS

a. Adjust high voltage to operating voltage of the detector being used. Use either of the two methods below.

(1) Refer to Figure 2-3 and set H.V. ADJUST to setting corresponding to voltage desired.

(2) Measure with electrostatic voltmeter. Record pot settings for future reference.

CAUTION

Use care not to over-voltage the G-M tube as permanent damage may result.

b. Set the gain control on the amplifier board to minimum (fully ccw).

c. Connect detector to DETECTOR connector.

d. Push RESET-START switch and expose detector to a check source. Instrument should count and is ready for operation.

2. SCINTILLATION DETECTORS

a. Connect detector to DETECTOR connector.

b. With the detector exposed to a radiation source of the isotope to be counted, run a plateau of counts vs. H.V. setting. (See Figure 2-4.)

c. Remove radiation source and repeat step b for background.

d. Set H.V. ADJUST to a point on the plateau just below the upswing of background.

3. PROPORTIONAL DETECTORS

a. Set the gain control on the amplifier board to maximum (fully cw). See Section IV, c, 2.

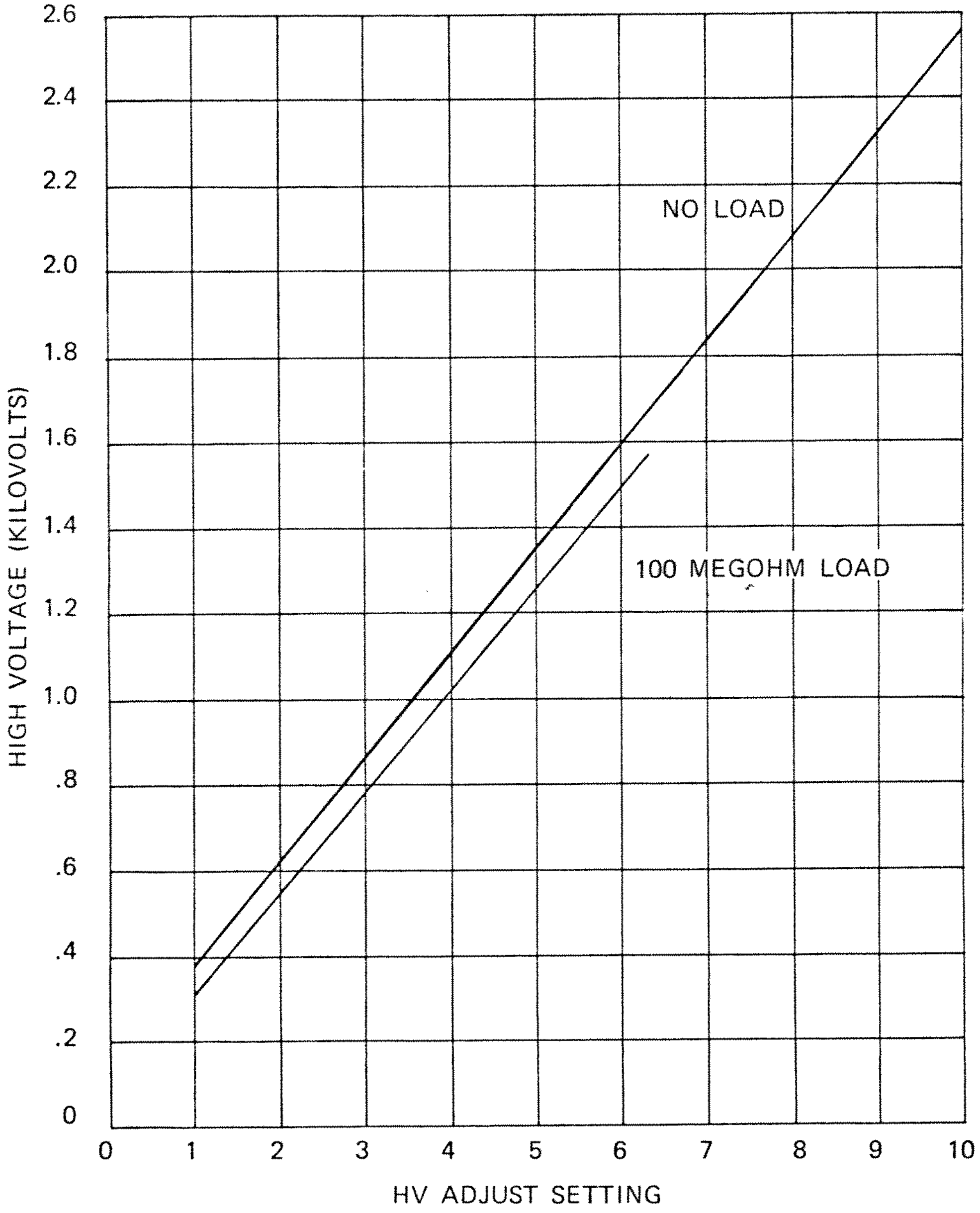


Figure 2-3. Typical High Voltage vs H. V. Adjust Setting

b. Plot a curve of counts versus HV setting with the detector exposed to an appropriate radiation field. (See Figure 2-5.)

c. Remove detector from the radiation source and plot a background curve.

d. Adjust high voltage for a point on the plateau below upswing of background.

e. Instrument is now ready for operation.

E. PRACTICAL CONSIDERATIONS OF COUNTING

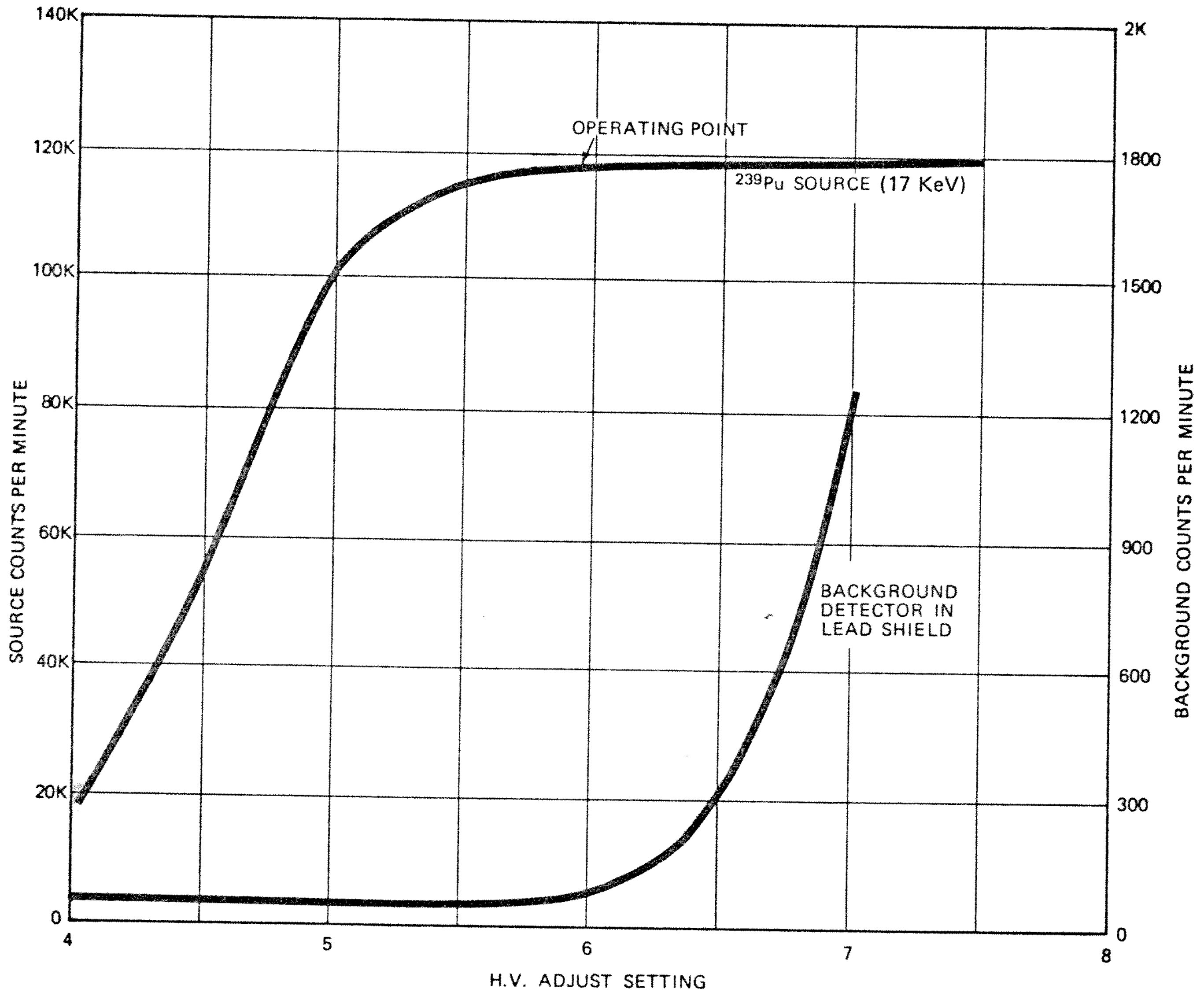


Figure 2-4. Typical H. V. Plateau, Model MS-3 with PG-2 Detector

RANDOM EVENTS (RADIOACTIVITY)

1. STATISTICAL DEVIATION

When the total number of counts recorded from a radioactive source is small, the number can be considerably different from the average source value due to statistical deviation.

The radiations from a source are random in nature and the laws of probability apply. From a determined number of counts the following equations can be used to calculate the deviation to be expected from the average source value.

A standard deviation (S.D.) is defined as the square root of the average total number of counts (N_A). The symbol for this is σ. Thus,

$$S.D. = \sigma = \sqrt{N_A} \qquad \text{Eq. I}$$

Any determination (N) on a sample will be within a certain deviation of the average a fixed percent of the time, as listed below.

$N = N_A \pm .674\sigma$	50% of the time	Eq. II
$N = N_A \pm \sigma$	68% of the time	Eq. III
$N = N_A \pm 2\sigma$	95% of the time	Eq. IV
$N = N_A \pm 3\sigma$	99.7% of the time	Eq. V

Example A: A 2500 CPM source is counted 100 times for 1 minute each.

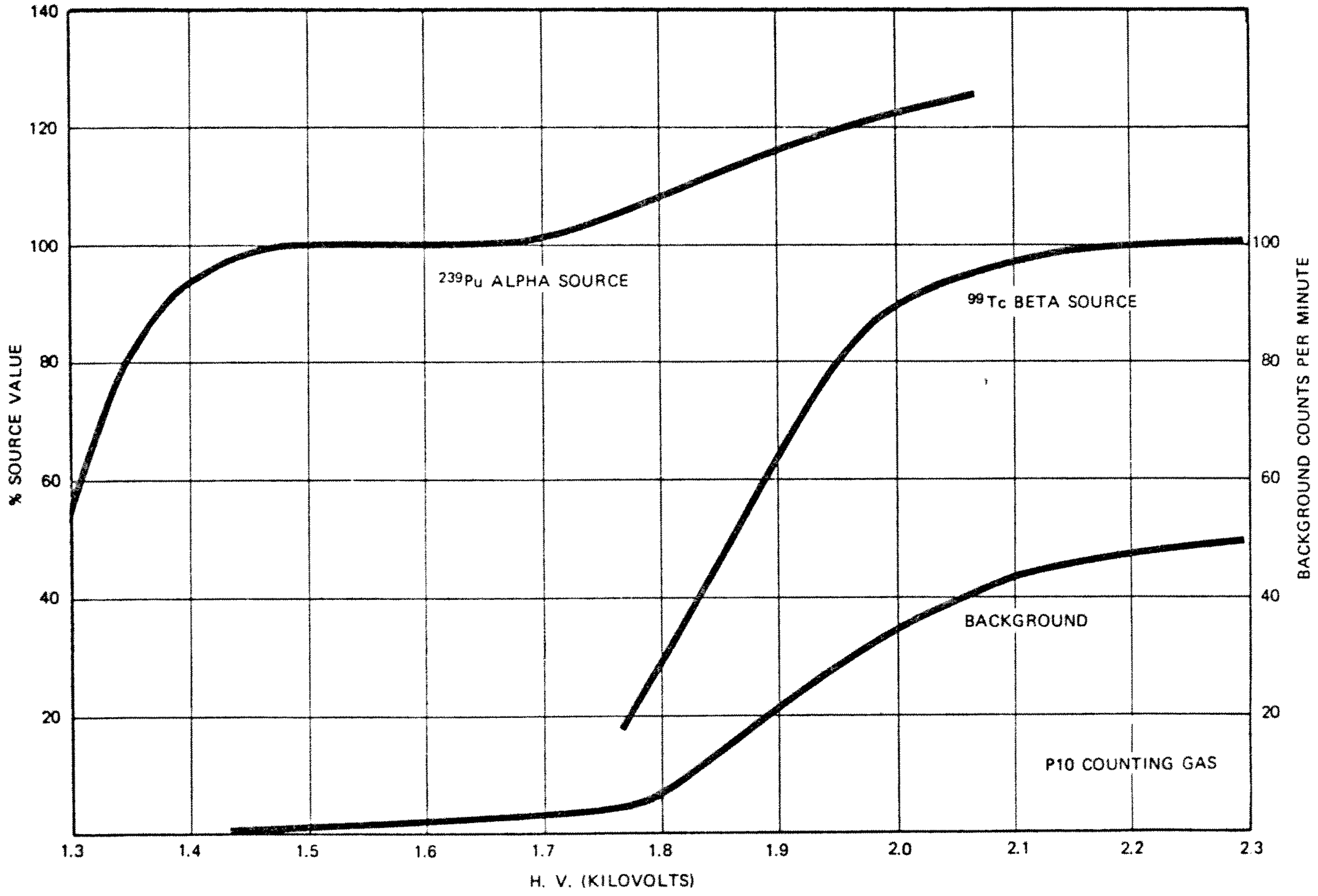


Figure 2-5. Typical Plateau, Model MS-3 with FC-2 Detector

From Eq. I, S.D. = $\sigma = \sqrt{2500} = 50$ CPM

The distribution of the individual counts will be as follows:

From Eq. II, 50 counts will be within 2500 ±34, or 2466 to 2534 CPM.

From Eq. III, 68 counts will be within 2500 ±50, or 2450 to 2550 CPM.

From Eq. IV, 95 counts will be within 2500 ±100, or 2400 to 2600 CPM.

From Eq. V, nearly all counts will be within 2500 ±150, or 2350 to 2650 CPM.

There is always the possibility that a count will be far away from the average, but this will happen only a small percentage of the time.

2. CONFIDENCE LEVEL

When the average count from a sample is not known and the accuracy of one determination must be specified, a confidence level must be used. Confidence level corresponds to the percentages in Equations II through V. At 50% confidence level, any one determination will be within $\pm .674\sigma$ of the average count. At the 95% confidence level, any one determination will be within $\pm 2\sigma$ of the average count.

Example B: A one minute determination on a sample reads 1747 counts. The standard deviation (σ) is 42. The accuracy of the determination can be specified as follows:

1747 ±28 CPM 50% confidence level or 1747 ±84 CPM 95% confidence level.

The 95% confidence level is in fairly common usage, however any level can be used as long as it is specified.

3. ERROR IN COMBINING TWO DETERMINATIONS

If the background count is comparable to the sample count, considerable error can be had in the solution when the background is subtracted out. The following formula applies:

$$R = R_S - R_B \pm 2\sqrt{\frac{R_S}{T_S} + \frac{R_B}{T_B}} \quad \text{95\% confidence level}$$

R = Net count of sample in counts per minute.
R_S = Count rate of sample and background in counts per minute,
R_B = Count rate of background in counts per minute,
T_S = Time that sample and background were counted in minutes,
T_B = Time that background was counted in minutes.

Example C: Background count is 20 counts in 10 minutes, and sample plus background count is 100 counts in 10 minutes. So,

$R_S = 100/10 = 10$ CPM
$R_B = 20/10 = 2$ CPM
$T_S = 10$ Minutes
$T_B = 10$ Minutes

$$R = 10 - 2 \pm 2\sqrt{\frac{10}{10} + \frac{2}{10}} = 8 \pm 2\sqrt{1.2} = 8 \pm 2.2 \text{ CPM } (8 \pm 27\tfrac{1}{2}\%)$$

at 95% confidence level.

To get the highest accuracy in the minimum amount of time, the sample counting time (T_S) and background counting time (T_B) should be distributed according to the following formula:

$$\frac{T_S}{T_B} = \sqrt{\frac{R_S}{R_B}}$$

4. RESOLVING TIME ERROR

When counting samples with a high count rate, the determination can be in error because of the finite resolving time of the counting system. The resolving time of a counter can be determined by counting two sources of approximately the same value individually and then together and applying the following formula:

$$\tau = \frac{R_1 + R_2 - R_{12}}{2(R_1 R_2)}$$

where:

τ = Resolving time (seconds)
R_1 = Counting rate, source 1 (counts per second)
R_2 = Counting rate, source 2 (counts per second)
R_{12} = Counting rate, source 1 + 2 (counts per second)

When the resolving time is known, an observed count can be corrected by applying the following formula:

$$R = \frac{R_o}{1 - R_o\tau}$$

where:

R = True counting rate (counts per second)
R_o = Observed counting rate (counts per second)
τ = Resolving time (seconds)

NOTE

Due to simplification of the above equations, the accuracy of the correction is limited if the correction exceeds about 20%.

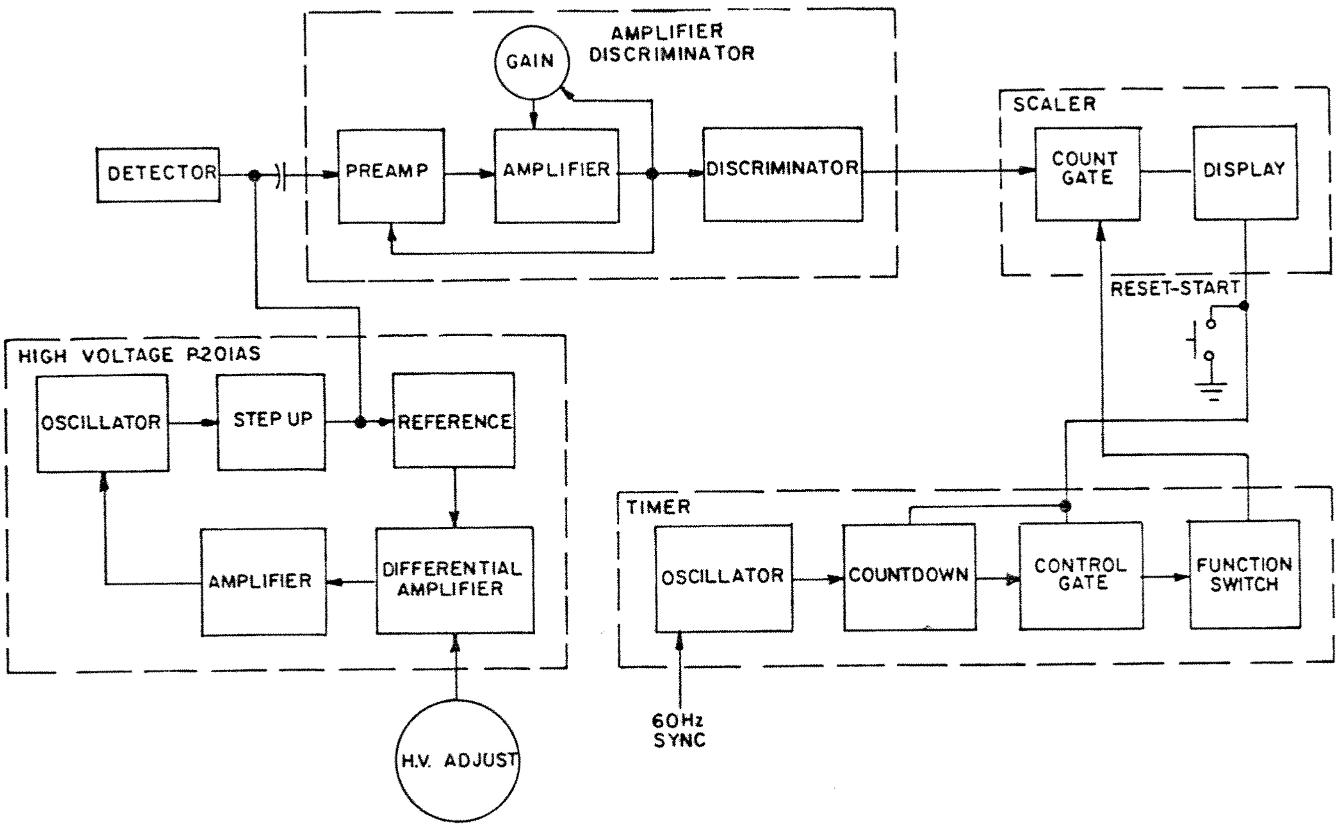


Figure 3-1. System Block Diagram

SECTION III
THEORY OF OPERATION

A. GENERAL (See Figure 3-1)

The high voltage power supply develops high voltage for the detector. When radiation reacts in the detector, negative pulses are generated. These pulses are coupled into an amplifier.

After amplification, the pulses are applied to a pulse height threshold discriminator.

The output of the discriminator is applied to a gate which is controlled either manually or by the timer, and counted by the scaler.

The timer uses line frequency for a time base and, when selected, controls the length of the time the count gate is open.

B. FUNCTIONAL THEORY

1. HIGH VOLTAGE SUPPLY (P-201AS)

This unit consists of a controlled oscillator (Q101), voltage step-up and rectification (T101), H. V. division (R106, R107, R108, R109 and R112), differential amplifier (Q104, Q105, Q106), amplifier (Q103) and oscillator control (Q102).

The regulation circuit is in balance when the voltages on Q104 gate and Q105 gate are equal. The high voltage will be a multiple of the voltage on the gates, approximately 800 times. The high voltage is varied by varying the voltage on the reference side (gate Q104) with R402, H.V. ADJUST. As the reference is increased, the differential amplifier is unbalanced, which increases the level of the oscillator and the high voltage output. This puts more current through the H.V. reference resistors, increasing the voltage on the sensing input (Q105 gate) and rebalances the circuit at a higher voltage.

A heavier load tends to lower the high voltage, unbalancing the differential amplifier. This increases the level of the oscillator, to maintain the original output.

Changes in power supply voltage are compensated by R110.

The differential amplifier is a matched pair (Q104, Q105) for temperature stability. Q106 is a current source.

2. AMPLIFIER

Transistors Q1 and Q2 form a charge sensitive preamplifier whose output is proportional to the charge input from the detector. The feedback capacitor C1 determines the sensitivity of this circuit. Constant current source CR2 sets Q1 bias current and, due to its high impedance, provides a very high voltage gain from Q1. Q2 is an emitter follower which provides a low output impedance from the preamplifier.

Transistors Q3 through Q7 are a dc coupled amplifier with feedback through R10 and R2 to control and stabilize the bias conditions. Gain is controlled by a feedback loop through R9 to the emitter of Q3. The resistance of R8 (Gain Control) forms a voltage divider with R9 to determine the gain.

3. TIMER

Integrated circuit A201 is connected as an oscillator whose frequency is adjustable by R205 and is set for 60 Hz. When the instrument is powered by the AC line, the oscillator is synchronized to line frequency via Q201.

Integrated circuits A202 and A203 are connected for divide-by-six countdowns reducing the frequency at A203 output (pin 8) to 100 pulses per minute. A204, A205 and A206 are divide-by-ten countdowns so the frequency at S201 wiper will be 10, 1 or .1 pulses per minute, depending on the switch position. A207 and S202 give the option of counting these frequencies down by either 2 or 5. (See Figure 3-2.) The section of A202 that is connected to the wiper of S202 sets the pulse in the right mode to control the gate (A208). The center two gates of A208 form a bi-stable flip-flop. The output of A208 (pin 11) is in a high state when counting and a low state when timed out.

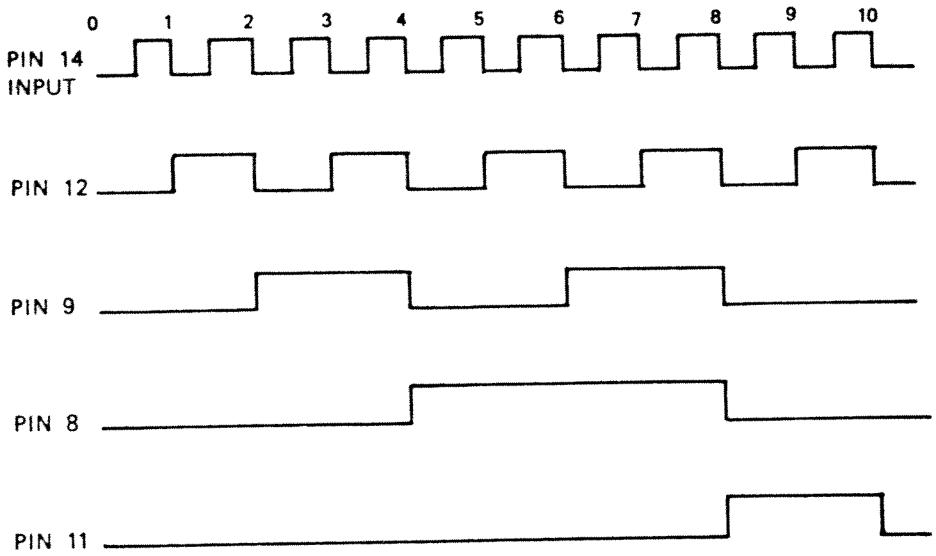
Integrated circuit A208 controls the count gate in the timed position of S203 and controls the reset and start action in the timer. Refer to Figure 3-3 for logic states.

4. SCALER

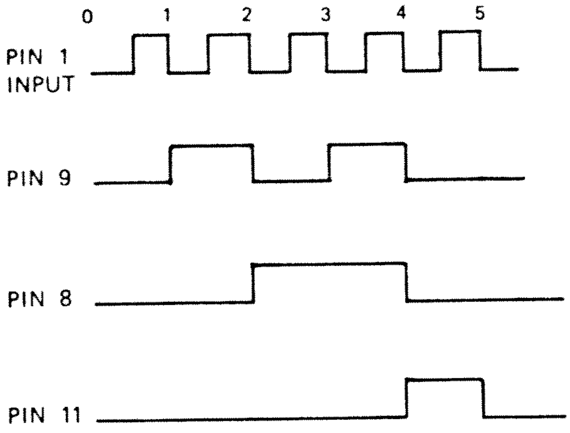
Integrated circuit A301 gates the signal to the scaler. If pin 13 is low (stop condition), no signal is on pin 11. If pin 13 is high (counting), signal on pin 12 is passed through to pin 11. The counting light is on when counting, and off when stopped.

Integrated circuits A302 through A307 are each a combination of decade counters, decoder-drivers, and seven segment light emitting diode displays.

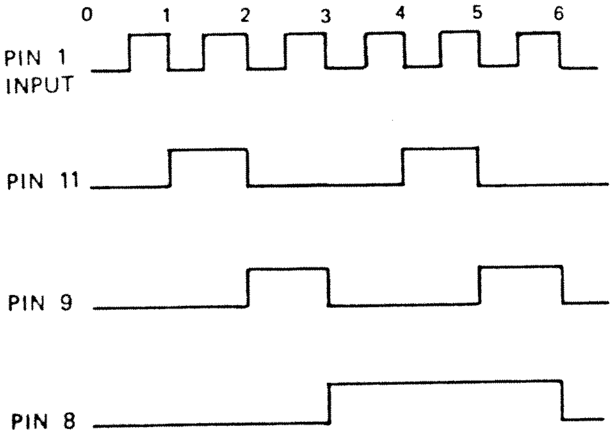
When the RESET-START switch is depressed, pin 12 of



a. 7490 in ÷ 10 MODE (A302 thru A307, A204, A205, A206)



b. 7490 in ÷ 5 MODE (A207)



c. 7492 in ÷ 6 MODE (A202, A203)

Figure 3-2. Counting Patterns for 7490 and 7492

the counters is held low which resets them to zero. Capacitor C301 holds the reset condition until any switching transients are clear.

5. LOW VOLTAGE SUPPLY

The AC line voltage is stepped down by T401 and rectified by A401. Voltage regulator A402 is a series regulator and supplies +5 volts to the circuitry. External battery connector, J402, is isolated by CR401. Zener diode CR402 limits the voltage to the high voltage power supply to 7.5 volts.

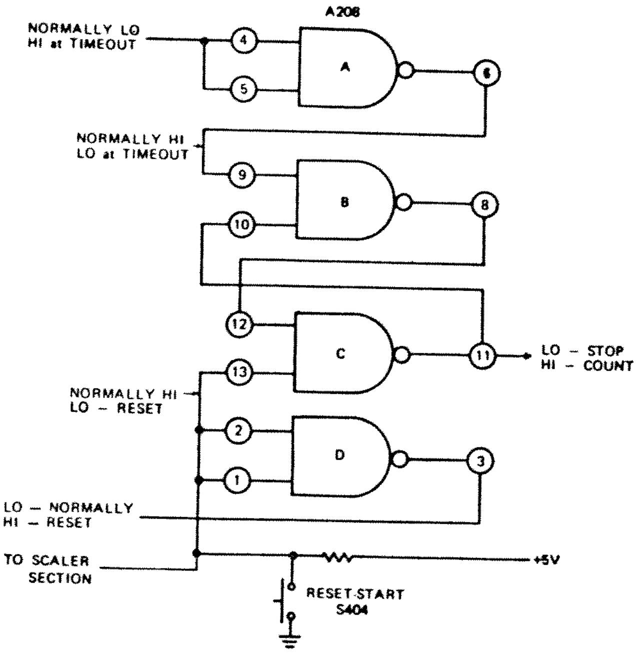


Figure 3-3. Logic States in Timer Control

SECTION IV
MAINTENANCE

A. DISASSEMBLY AND REASSEMBLY

1. To remove cover, remove one 10-32 screw on each side and lift off cover.

CAUTION

> Severe shock can occur from the charge on filter capacitor C402. Make sure high voltage has been shorted out by shorting the detector connector center pin to ground.

2. To remove high voltage supply, remove hold-down screw and lift from socket.

3. To remove amplifier-discriminator board, remove the four 4-40 screws on the board. Unsolder C403 and tilt board up for access to bottom side.

4. To remove timer board, remove amplifier-discriminator board first. Remove the front left spacer of the amplifier-discriminator board. Remove the four 4-40 screws that hold the timer board in place. Slide the timer board back and tilt to center of chassis for access to the bottom of the board.

5. To remove scaler board, remove the three nuts that hold the scaler board to the chassis. Swing the board toward the center of the chassis for access to the front side of the board.

6. To reassemble, reverse procedures.

B. PREVENTIVE MAINTENANCE

1. Keep the instrument clean and dry.

2. The MS-3 has no components that require scheduled maintenance.

C. CALIBRATION

1. TIMER

The timer can be modified to run synchronized to a 50 Hz line or to run with no sync input at all. The following shows the changes to be made.

a. Synchronized to 50 Hz line: This modification may be accomplished by removing A203 from the timer board and replacing it with a type 7490 integrated circuit. If this change is made, you must check to see that pins 2 and 3 of the socket for A203 are jumpered to ground. For calibration of the oscillator for battery operation, see below.

b. No external sync signal: To modify the timer to run on its own oscillator with no external sync signal, remove the wire from tie point 6 of the timer board. The line sync feature is then disconnected.

c. Calibration of oscillator: Either of the two methods given below may be used.

(1) Using an oscilloscope and monitoring at tie point 7 of the timer board, adjust R205 for 60 Hz (16-2/3 milliseconds period) if the timer board is not modified or if it is modified according to part b above.

If the timer board is modified for syncing with a 50 Hz line, then adjust R205 for 50 Hz (20 milliseconds period).

(2) Connect a pulse generator with an accurate base (such as EIC Model MP-1) to the amplifier input. Preset a time and adjust R205 for the correct reading on the scaler.

2. AMPLIFIER GAIN

The gain of the amplifier is set at the factory for approximately 1.25 volt output with a 10 millivolt input. On scintillation and proportional detectors, the high voltage also controls the overall gain, so the gain adjustment is arbitrary. The gain control, however, can be adjusted to suit the operator and/or detector. Generally, the gain should be set high (toward maximum clockwise) for proportional and scintillation detectors and low (minimum) for geiger detectors. Refer to Section II, D for setup procedures for this particular detector.

When adjusting the gain toward maximum, be sure that noise can be rejected.

D. TROUBLESHOOTING

Typical voltages and waveforms are given on the schematic. Use of the schematic, along with the Theory of Operation section and its waveforms and diagrams, should help to isolate and pinpoint problems. Component locations are shown in Section VI.

Voltages, except the high voltage, are measured with a

20,000 ohms per volt, or greater, voltmeter. An electrostatic voltmeter should be used to measure the high voltage.

If an electrostatic voltmeter is not available for measuring high voltage, the voltmeter used for the other voltages may be used to give an indication of high voltage. It must be remembered, however, that this is an indication only.

SECTION V
PARTS LIST

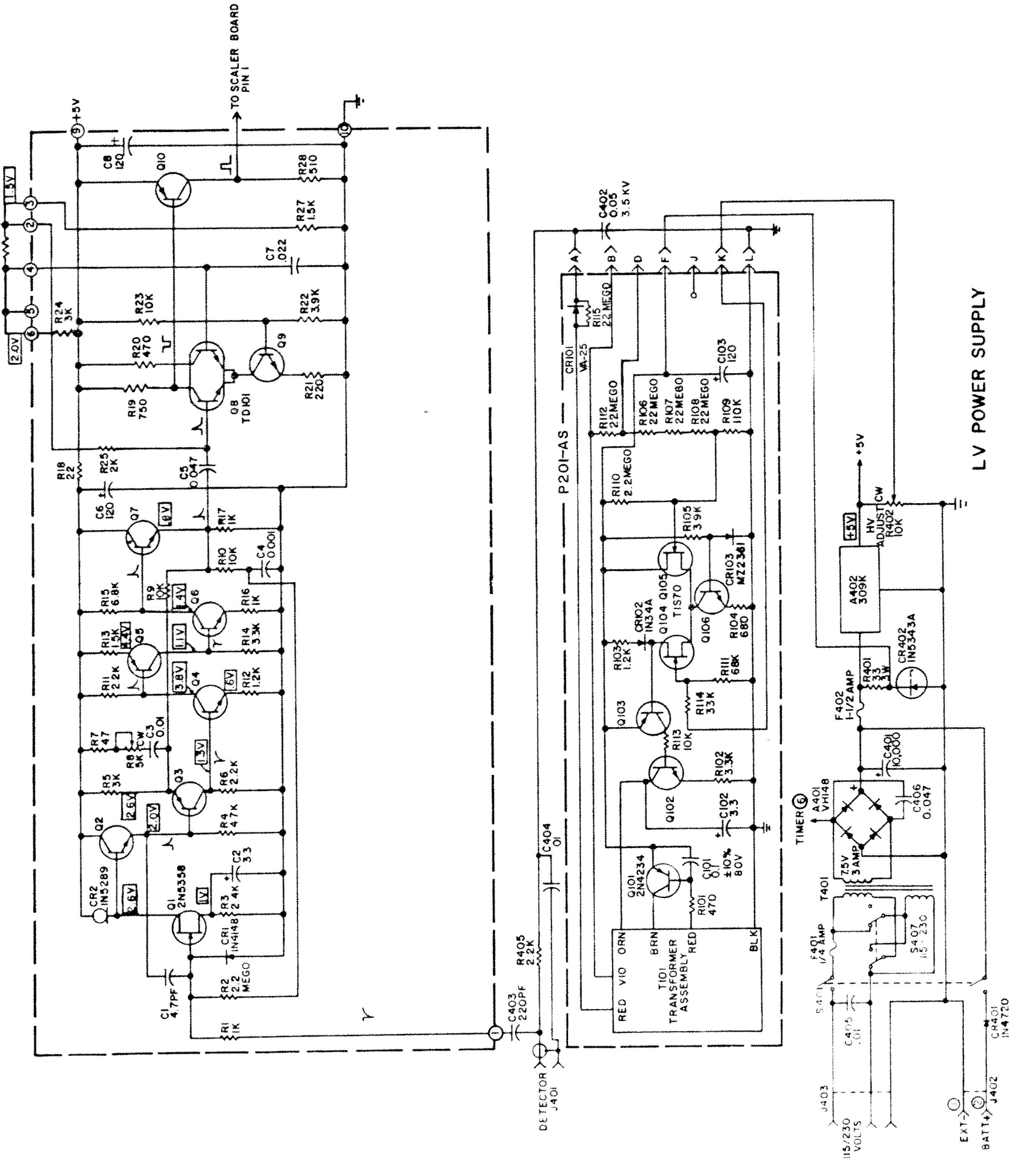
REF DESIG	PART	DESCRIPTION	MFR AND PART NO
1. SCALER			
A301	Integrated Circuit	Quad 2 Input NAND Gate	Fairchild U6A740059X or equivalent
A302, A303, A304, A305, A306, A307	Integrated Circuit	Decade Counter Readout	TI TIL306 or TIL307
C301	Capacitor	1.0 mfd, 35V	Type CS13 Case A
DS301	Diode	Light Emitting	Monsanto MV5021
R301	Resistor	680 ±10%, 1/4W	
R302	Resistor	10K ±10%, 1/4W	
2. TIMER			
A201	Integrated Circuit	Quad 2 Input NOR Gate	RCA CD4001AE
A202, A203	Integrated Circuit	Divide-by-12 Counter, Type 7492, DIP, 70°C	Fairchild U6A749259X
A204, A205, A206, A207	Integrated Circuit	Decade Counter, Type 7490, DIP, 70°C	Fairchild U6A749059X or equivalent
A208	Integrated Circuit	Quad 2 Input NAND Gate, Type 7400, DIP, 70°C	Fairchild U6A740059X or equivalent
C201	Capacitor	.01 μF, 200V	Sprague 192P-10392
C202	Capacitor	.047 μF, ±10%, 100V	Sprague 227P-47391
C203	Capacitor	120 μF, 10V	Type CS13 Case C
Q201, Q202	Transistor	NPN, Silicon	Type 2N4124
R201	Resistor	27K, ±10%, 1/4W	
R202	Resistor	68K, ±10%, 1/4W	
R203	Resistor	12K, ±5%, 1/4W	
R204	Resistor	10K, ±10%, 1/4W	
R205	Potentiometer	100K	Bourns 3299W-1-104
R206	Resistor	120K, ±5%, 1/4W	
R207	Resistor	750K, ±5%, 1/4W	
R208	Resistor	47K, ±10%, 1/4W	
R209	Resistor	4.7K, ±10%, 1/4W	
S201, S202, S203	Switch	2-Pole, 3-Position Slide	Cont. Wirt G-386-PC

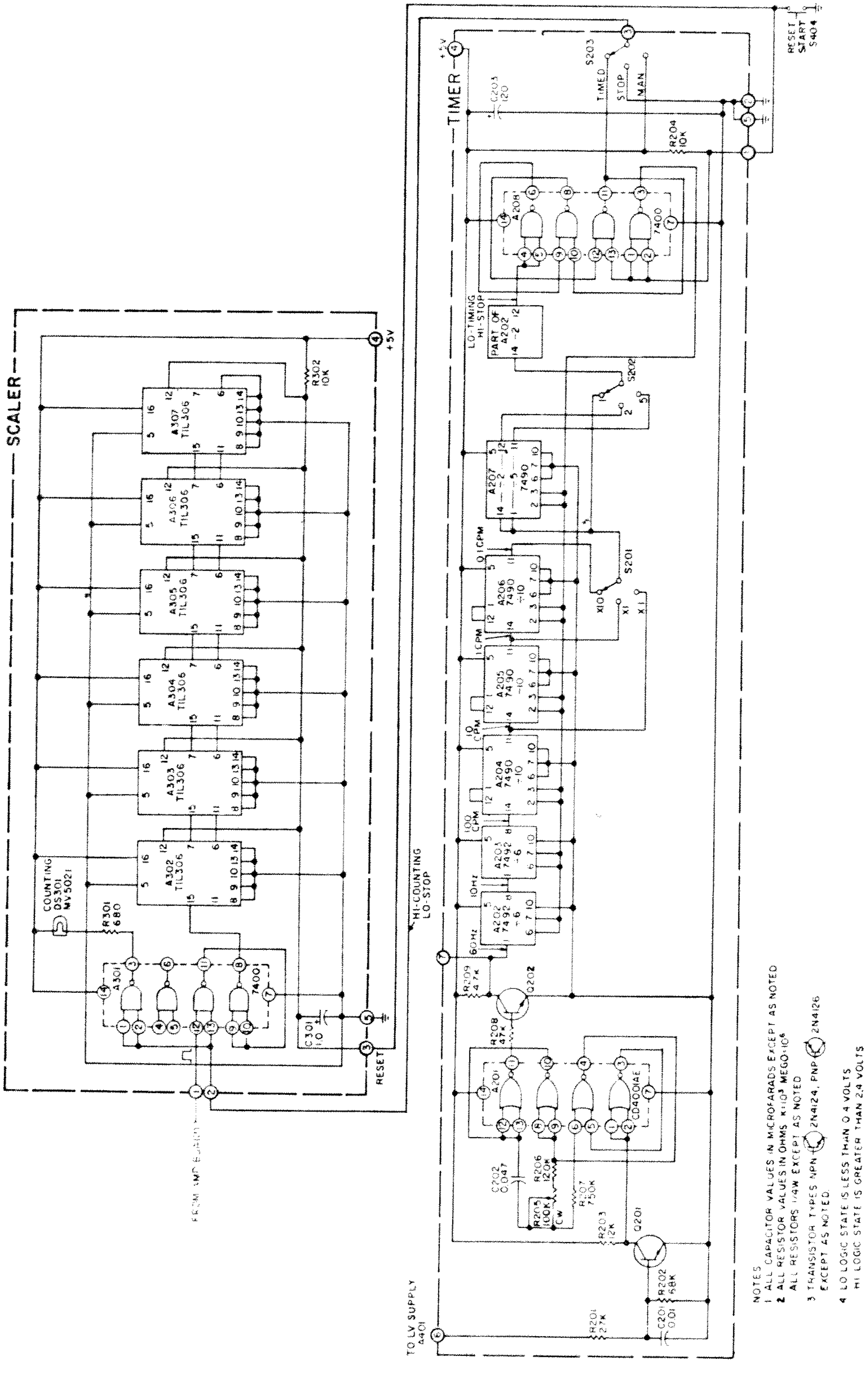
REF DESIG	PART	DESCRIPTION	MFR AND PART NO
3. AMPLIFIER-DISCRIMINATOR			
C1	Capacitor	4.7 pF, 1000V	Sprague 10TCC-V47
C2	Capacitor	3.3 μF, ±10%, 15 V	Type CS13 Case A
C3	Capacitor	0.01 μF, ±10%, 200 V	Sprague 192P-10392
C4	Capacitor	0.001 μF, ±10%, 200 V	Sprague 192P-10292
C5	Capacitor	0.047 μF, ±10%, 100 V	Sprague 225P-47391
C6, C8	Capacitor	120 μF, 10 V	Type CS13 Case C
C7	Capacitor	0.022 μF, ±10%, 200 V	Sprague 192P-22392
CR1	Diode		Type 1N4148
CR2	Current Source	0.43 milliamp	Type 1N5289
Q1	JFET		Type 2N5358
Q2, Q4, Q6, Q7, Q9	Transistor	NPN, Silicon	Type 2N4124
Q3, Q5, Q10	Transistor	PNP, Silicon	Type 2N4126
Q8	Transistor	Dual NPN	Sprague TD101
R1, R16, R17	Resistor	1K, ±10%, 1/4W	
R26, R28	Resistor	510, ±5%, 1/4W	
R2	Resistor	2.2 mego, ±10%, 1/4W	
R3	Resistor	2.4K, ±5%, 1/4W	
R4	Resistor	4.7K, ±10%, 1/4W	
R5, R24	Resistor	3K, ±5%, 1/4W	
R6, R11	Resistor	2.2K, ±5%, 1/4W	
R7	Resistor	47 ohms, ±10%, 1/4W	
R8	Potentiometer	5K	Bournes 325W-1-502
R9, R10, R23	Resistor	10K, ±10%, 1/4W	
R12	Resistor	1.2K, ±5%, 1/4W	
R13, R27	Resistor	1.5K, ±5%, 1/4W	
R14	Resistor	3.3K, ±5%, 1/4W	
R15	Resistor	6.8K, ±5%, 1/4W	
R18	Resistor	22 ohms, ±10%, 1/4W	
R19	Resistor	750, ±10%, 1/4W	
R20	Resistor	470 ohms, ±10%, 1/4W	
R21	Resistor	220 ohms, ±10%, 1/4W	
R22	Resistor	3.9K, ±10%, 1/4W	
R25	Resistor	2K, ±5%, 1/4W	
4. CHASSIS			
A401		Bridge Rectifier	Varo VH-148
A402		Voltage Regulator, 5 V	National LM309K or FSC UGJ7109393
C401	Capacitor	10,000 μF, 15 V	Aerovox PRS-1244 or ARCO CTA 1103
C402	Capacitor	.05 μF, 3.5 KV	Capco, EBL-1
C403	Capacitor	220 pF, 3 KV	CRL DD30-221
C404, C405	Capacitor	0.01 μF, 3 KV	Sprague 30GA-S10 or equivalent
C406	Capacitor	0.047 μF, 200 V	Sprague 192P-47392
CR401	Diode		Type 1N4720
CR402	Diode	7.5 V Zener	Type 1N5343A

REF DESIG	PART	DESCRIPTION	MFR AND PART NO
4. CHASSIS (Continued)			
F401	Fuse	1/4 amp, Slo-Blo, 3AG Size	
F402	Fuse	1-1/2 amp, 3AG Size	
R401	Resistor	33 ohms, 3W	Sprague 242E3305
R402	Potentiometer	10K, 10-Turn	Beckman Helipot 7276
R405	Resistor	2.2K, ±10%, 1/4W	
S401	Switch	Toggle, DPDT (POWER)	Alco MST-205N
S404	Switch	Push Button, N.O.	Grayhill 39YY2035
S407	Switch	Slide, DPDT (115-230 VAC)	Cont. Wirt GF-326
T401	Transformer	115-230V Primary; 7.5V, 3A Secondary	Zenith WE2274
5. HV SUPPLY, P-201AS			
C101	Capacitor	0.1 μF, ±10%, 80V	Sprague 192P-1049R8
C102	Capacitor	3.3 μF, ±20%, 15V	Type CS13 Case A
C103	Capacitor	120 μF, ±20%, 10V	Type CS13 Case C
CR101	Diode	2500 PIV	Varo VA-25 or equivalent
CR102	Diode	Germanium	Type 1N34A
CR103	Diode	Dual Junction	Motorola MZ2361
Q101	Transistor		Type 2N4234
Q102, Q106	Transistor		Type 2N4124
Q103	Transistor		Type 2N4126
Q104, Q105	Transistor	Matched Pair FET	Eberline 10519-A04
R101	Resistor	470 ±10%, 1/4W	
R102	Resistor	3.3K, ±10%, 1/4W	
R103	Resistor	1.2K, ±10%, 1/4W	
R104	Resistor	680 ±10%, 1/4W	
R105	Resistor	3.9K, ±10%, 1/4W	
R106, R107, R108	Resistor	22 mego, ±5%, 1/4W	
R109	Resistor	110K, ±5%, 1/4W	
R110	Resistor	2.2 mego, ±10%, 1/4W	
R111	Resistor	68K, ±5%, 1/4W	
R112	Resistor	22 mego, ±5%, 1/4W	
R113	Resistor	10K, ±10%, 1/4W	
R114	Resistor	33K, ±5%, 1/4W	
R115	Resistor	22 mego, 10%, 1/8W	
T101	Transformer Assembly		EIC 10417-C01

SECTION VI

DIAGRAMS





NOTES
1 ALL CAPACITOR VALUES IN MICROFARADS EXCEPT AS NOTED
2 ALL RESISTOR VALUES IN OHMS K=10³ MEG=10⁶
ALL RESISTORS 1/4W EXCEPT AS NOTED
3 TRANSISTOR TYPES NPN 2N4124, PNP 2N4126
EXCEPT AS NOTED.
4 LO LOGIC STATE IS LESS THAN 0.4 VOLTS
HI LOGIC STATE IS GREATER THAN 2.4 VOLTS

Figure 6-1. General Schematic, Model MS-3

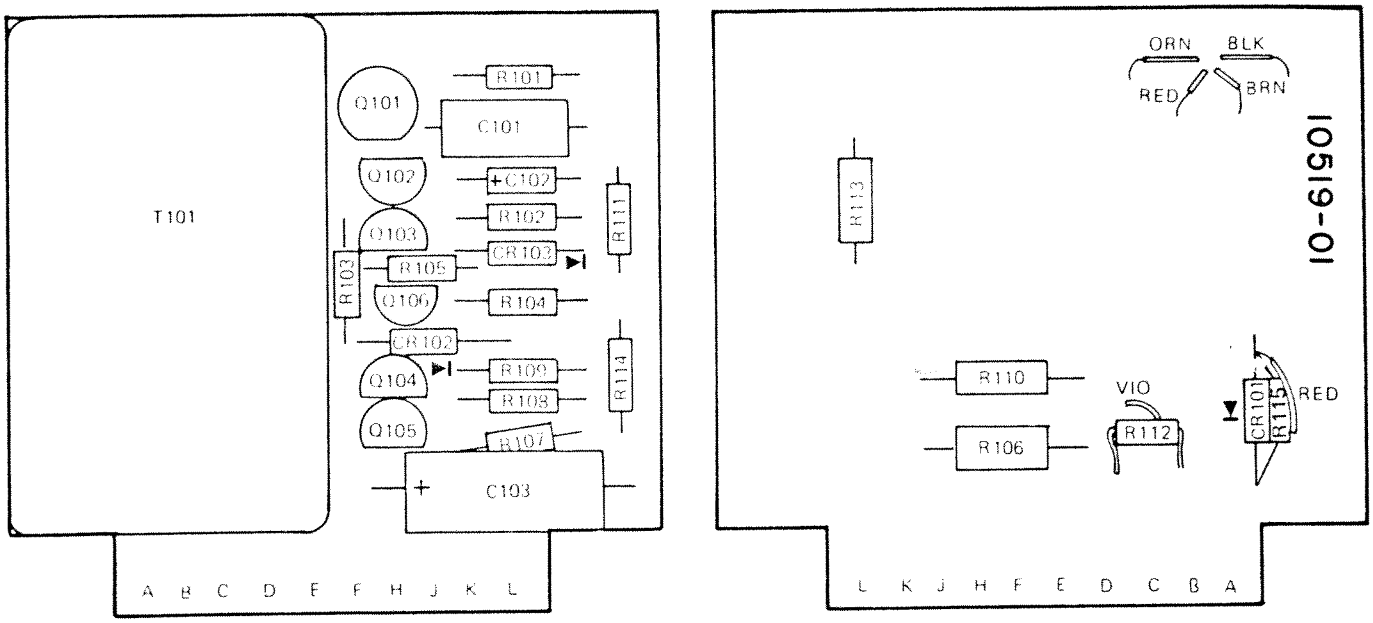


Figure 6-2. Component Layout of P-201AS Board

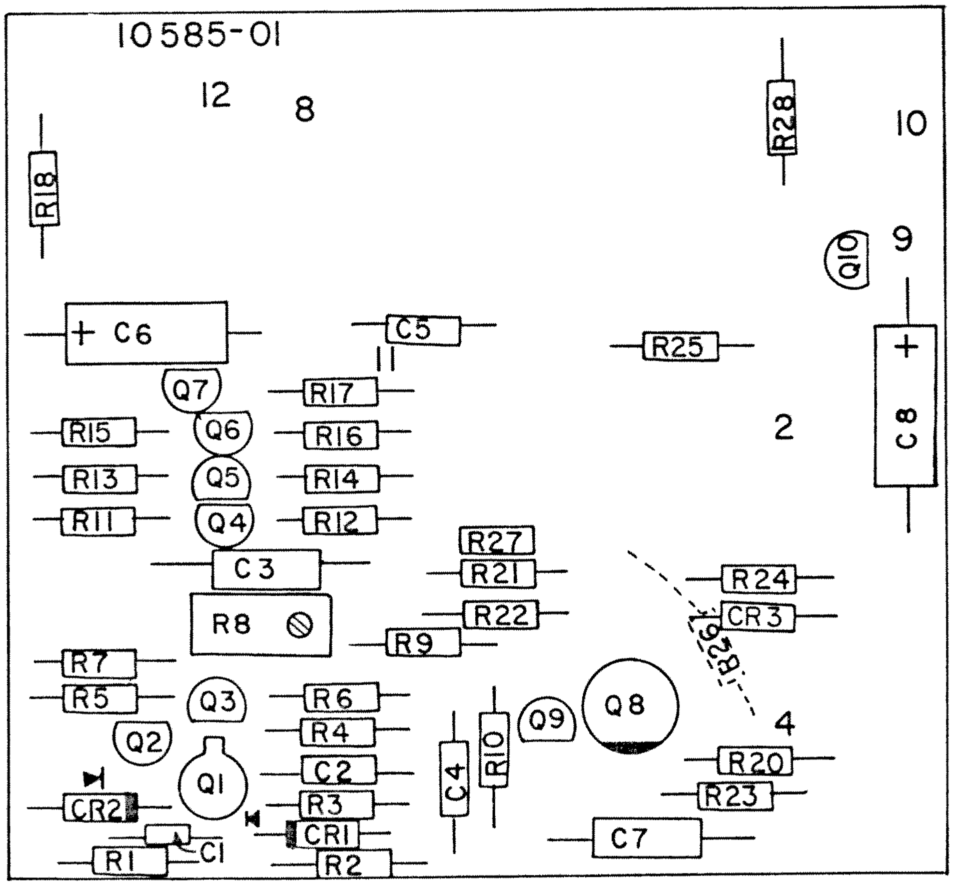


Figure 6-3. Component Layout of Amplifier-Discriminator Board

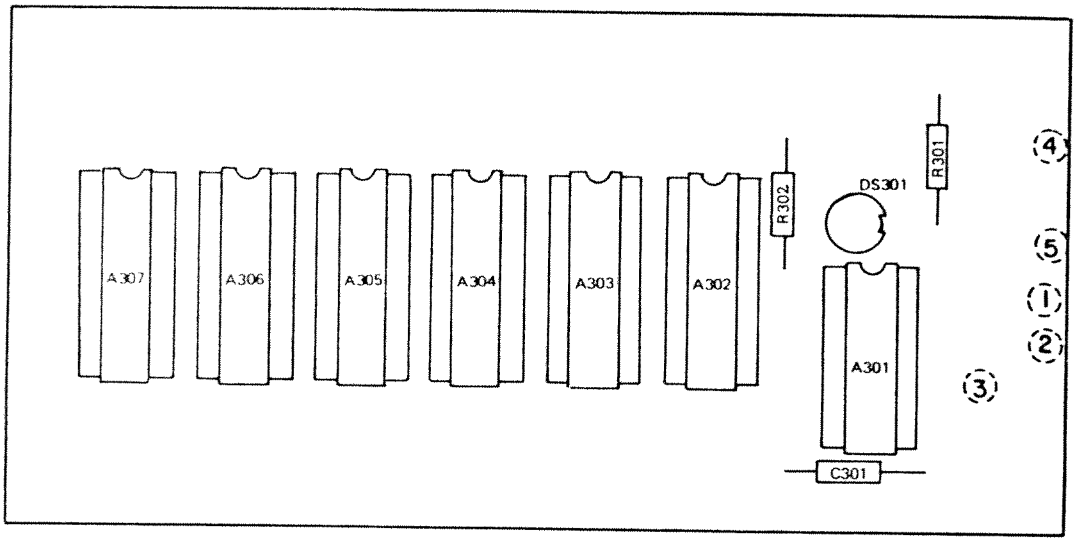


Figure 6-4. Component Layout of Scaler Board

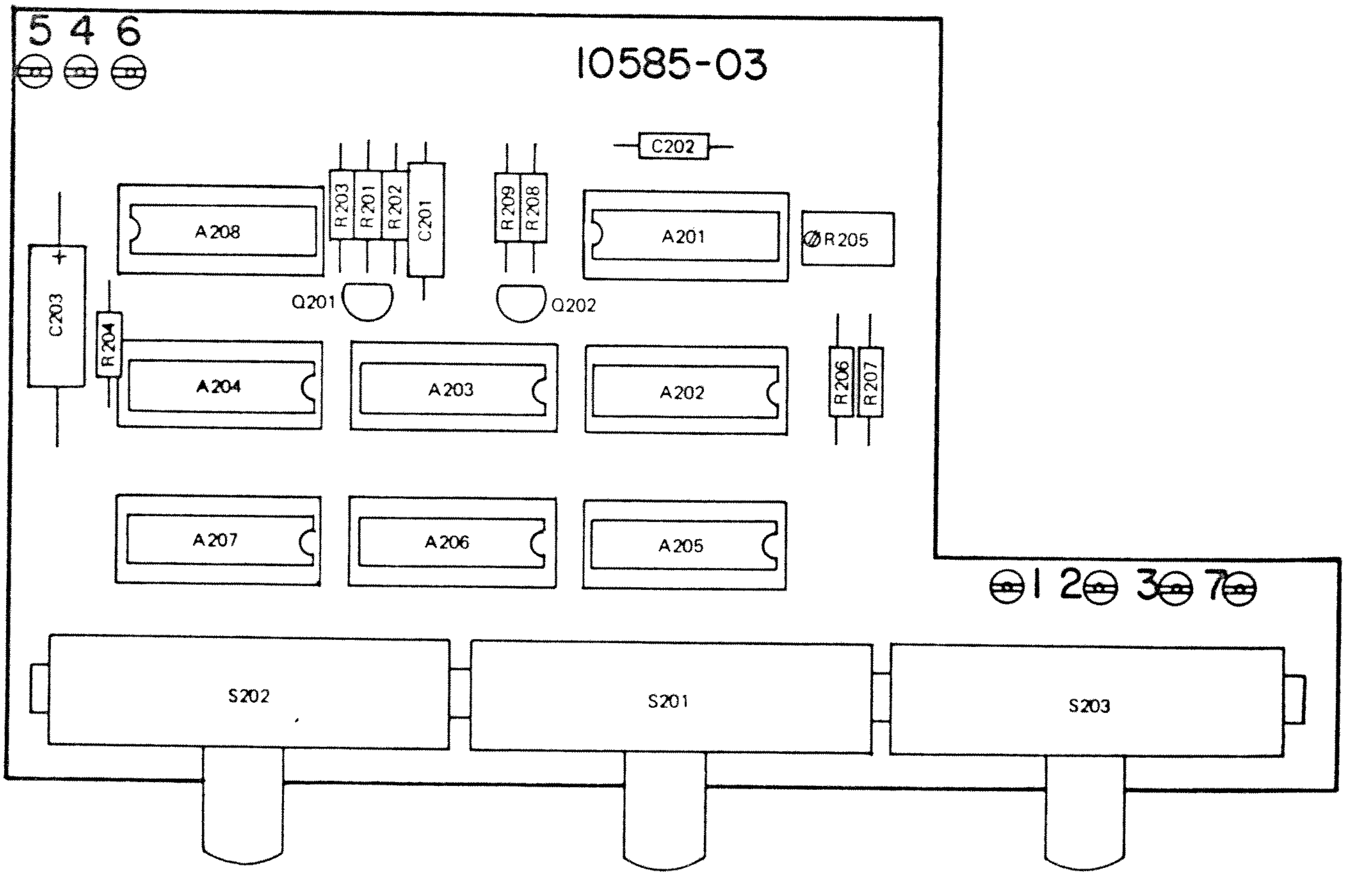


Figure 6-5. Component Layout of Timer Board

NO.	QUAN.	PER.	DESCRIPTION

CHG.	APP.	DATE	DESCRIPTION	DATE	BY	CH'K
D	[illegible]	1/20/77	SHT 3: ¶ C-7, add "minimum sensitivity" provision	1/20/77	BK	
C	[illegible]	12/29/76	SHT 3: ¶ C-7, 10 mV was 24 mV.	12/29/76	BK	[illegible]

APP. REV D 1-21-77

EBERLINE INSTRUMENT CORPORATION
SANTA FE, NEW MEXICO

DR.		
CH'K.		
PROJ. ENG.	LO	
APP.	ELB	5/30/73

MS-3

CHECKOUT PROCEDURE

DIMENSIONAL TOLERANCES
UNLESS OTHERWISE SPECIFIED

FRAC.	DEC.	ANG.
± 1/64	X.XX ± .015 X.XXX ± .005	± 1/2°

ALSO USED ON	EFF. WITH

SCALE

10429-A92 D

Sheet 1 of 3

A. Plug instrument into line. Check following voltages, using D.V.M. (without P-201A installed):

1. Amplifier board, pin 9; scaler board, pin 4; timer board, pin 4: 5.0 ±0.2 volts.
2. P-201A, pin F: 6.75 - 8.25 volts.
3. Amplifier Board:
    a. Check the voltage at Q7 emitter. If it is between .6 and 1.0 volt, go on to step 4. If it is outside these limits, check all the voltages in "b" below and correct, as necessary, if they are out of the limits called out in b.
    b. Q1 source - .85-1.18 volts
    Q1 drain - 2.33-2.9 volts
    Q2 emitter - 1.63-2.3 volts
    Q3 emitter - 2.33-2.9 volts
    Q3 collector - 1.15-1.46 volts
    Q4 emitter - .55-.76 volt
    Q4 collector - 3.62-3.92 volts
    Q5 emitter - 4.22-4.52 volts
    Q5 collector - 1.05-1.28 volts
    Q6 collector - 1.05-1.78 volts
    Q7 emitter - .45-1.08 volts

B. Control Circuitry

1. Set mode switch to MAN.
    a. Counting light should light.
2. Set mode switch to STOP.
    a. Unit should stop counting; counting light goes out.
3. Push RESET-START switch.
    a. All decades reset to zero.
4. Set mode switch to TIMED, timer switches to 0.1 minute and push RESET-START switch.
    a. Unit should stop counting after 6 seconds.

C. Amplifier - PHA

1. Turn mode switch to MAN.
2. Turn GAIN pot maximum. (cw)
3. Connect MP-1 to DETECTOR connector.
4. Using a scope, set pulse height at the base of Q3 to 0.05 volts by adjusting the MP-1. Output of amplifier (C5/R25 jct) should be 2.5 volts or greater.
5. Turn GAIN pot to minimum. (ccw)

6. Repeat step 6 except output of amplifier should be 0.25 volts maximum, 0.15 volts minimum.
7. △ △ Adjust GAIN pot to max. and min. SENS should vary from approximately 1 mV to 10 mV. Set GAIN pot for 10 millivolt input sensitivity or minimum sensitivity if 10 millivolts is not attainable.

D. Timer

1. Set mode switch to TIMED position.
2. Set MP-1 to 1000 CPM.
3. Set time to 0.1 minute.
4. Push RESET-START switch. Counter should stop at 98-102 counts.
5. Set time to .2 minute and push RESET-START. Counter should stop at 198-202 counts.
6. Set time to .5 minute and push RESET-START. Counter should stop at 490-510 counts.
7. Set time to 10 minutes and push RESET-START. Counter should stop at 9975-10,025 counts.
8. Disconnect from AC line and plug in battery.
9. With scope at pin 7, adjust frequency for 60 Hz (16.7 milliseconds).
10. With MP-1 at 1000 CPM, recheck step 5. Count should be 196-204.

E. Scaler

1. Check all numbers on all decades for lighting and correct counting.

F. High Voltage

1. Disconnect from battery and plug back into AC line.
2. Plug P-201AS into its socket.
3. Check the following H.V. ADJUST control settings using an electrostatic voltmeter on pin A of P-201AS.

H.V. ADJUST	HIGH VOLTAGE
3.30	900 ± 50 volts
10.00	2500 ± 100 volts